CHAPTER 7

SCREENING

7-1. General considerations. Screening is a process necessary to protect pumps and subsequent treatment units of a wastewater treatment plant. Its main function is to remove sticks, stones, rags, trash, and other debris.

7-2. Bar screens.

a. Description and function. The primary function of coarse screening is protection of downstream facilities rather than effective removal of solids from the plant influent. All screens used in sewage treatment plants or in pumping stations may be divided into the following classifications:

(1) Trash racks, which have a clear opening between bars of 1-1/2 to 4 inches and are usually cleaned by hand, by means of a hoist, or possibly by a power-operated rake.

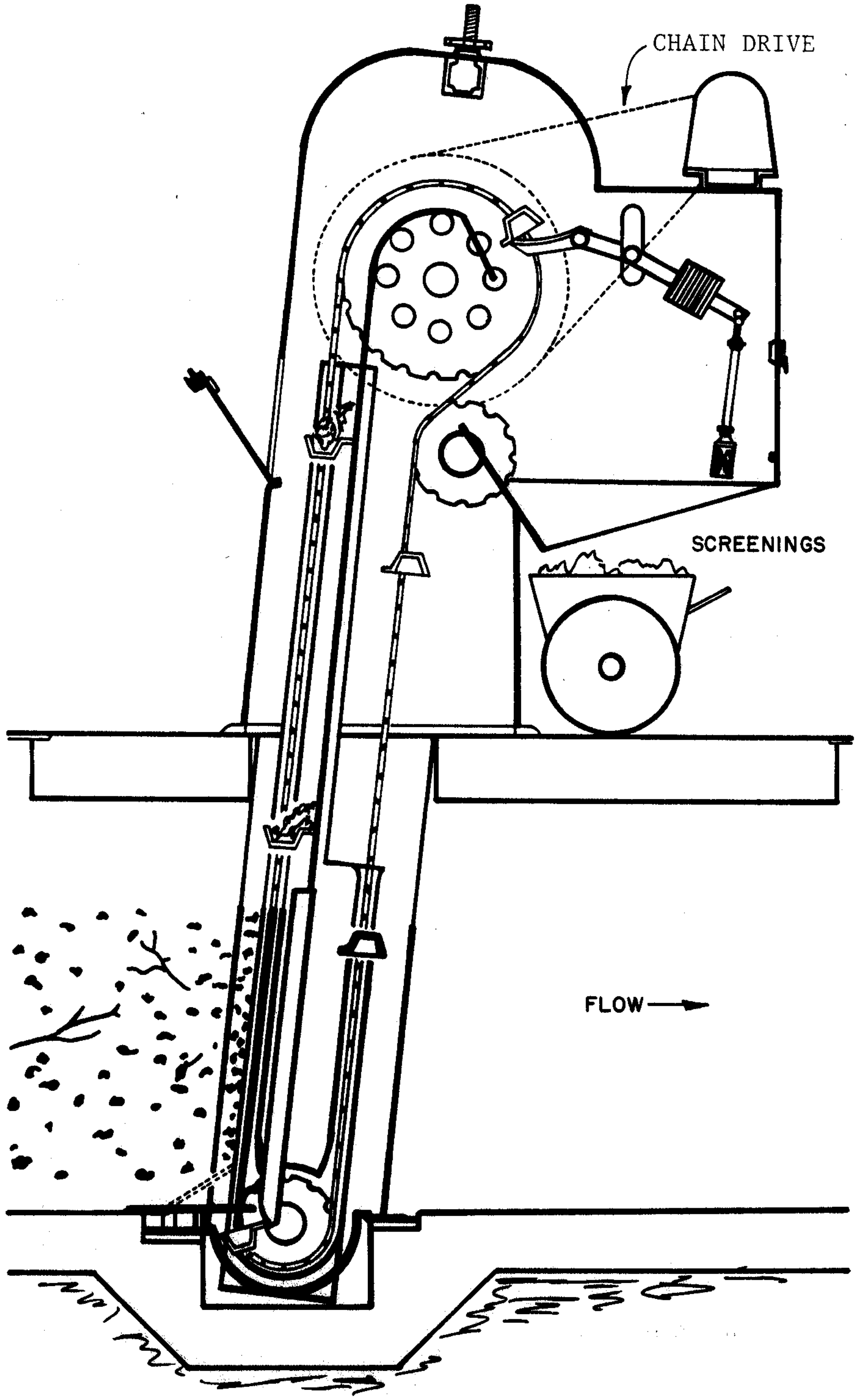
(2) Standard mechanically cleaned bar screen, with clear openings from 1/2 to 1-1/2 inches (figure 7-1).

(3) Fine screen, with openings 1/4 inch wide or smaller.

b. Design basis. Screens will be located where they are readily accessible. An approach velocity of 2 fps, based on average flow of wastewater through the open area, is required for manually cleaned bar screens. For mechanically cleaned screens, the approach velocity will not exceed 3.0 fps at maximum flows.

(1) Bar spacing. Clear openings of 1 inch are usually satisfactory for bar spacing, but 1/2 to 1-1/2 inch openings may be used. The standard practice will be to use 5/16-inch by 2-inch bars up to 6 feet in length and 3/8-inch by 2-inch or 3/8-inch by 2-1/2-inch bars up to 12 feet in length. The bar will be long enough to extend above the maximum sewage level by at least 9 inches.

(2) Size of screen channel. The maximum velocity through the screen bars, based on maximum normal daily flow, will be 2.0 fps. For wet weather flows or periods of emergency flow, a maximum velocity of 3.0 fps will be allowed. This velocity will be calculated on the basis of the screen being entirely free from debris. To select the proper channel size, knowing the maximum storm flow and the maximum daily normal flow, the procedure is as follows: the sewage flow (mgd) multiplied by the factor 1.547 will give the sewage flow (cfs). This flow in cfs divided by the efficiency factor obtained from table 7-1 will give the wet area required for the screen channel. The minimum width of the channel should be 2 feet, and the maximum width of the



Envirex Inc. (Noncopyrighted)

FIGURE 7-1. SCHEMATIC OF HEAVY DUTY MECHANICALLY CLEANED BAR SCREEN channel should be 4 feet. As a rule it is desirable to keep the sewage in the screen channel as shallow as possible in order to keep down the head loss through the plant; therefore, the allowable depth in the channel may be a factor in determining the size of the screen. In any event, from the cross-sectional area in the channel, the width and depth of the channel can be readily obtained by dividing the wet area by the depth or width, whichever is the known quantity.

Table 7-1. Efficiencies of Bar Spacing

Bar Size inches	Openings inches	Efficiency
1/4	1	0.800
5/16	1	0.768
3/8	1	0.728
7/16	1	0.696
1/2	1	0.667

(3) Velocity check. Although screen channels are usually designed on the basis of maximum normal flow or maximum storm flow, it is important to check the velocities which would be obtained through the screen from minimum or intermediate flows. The screen will be designed so that at any period of flow the velocities through the screen do not exceed 3 fps under any flow condition.

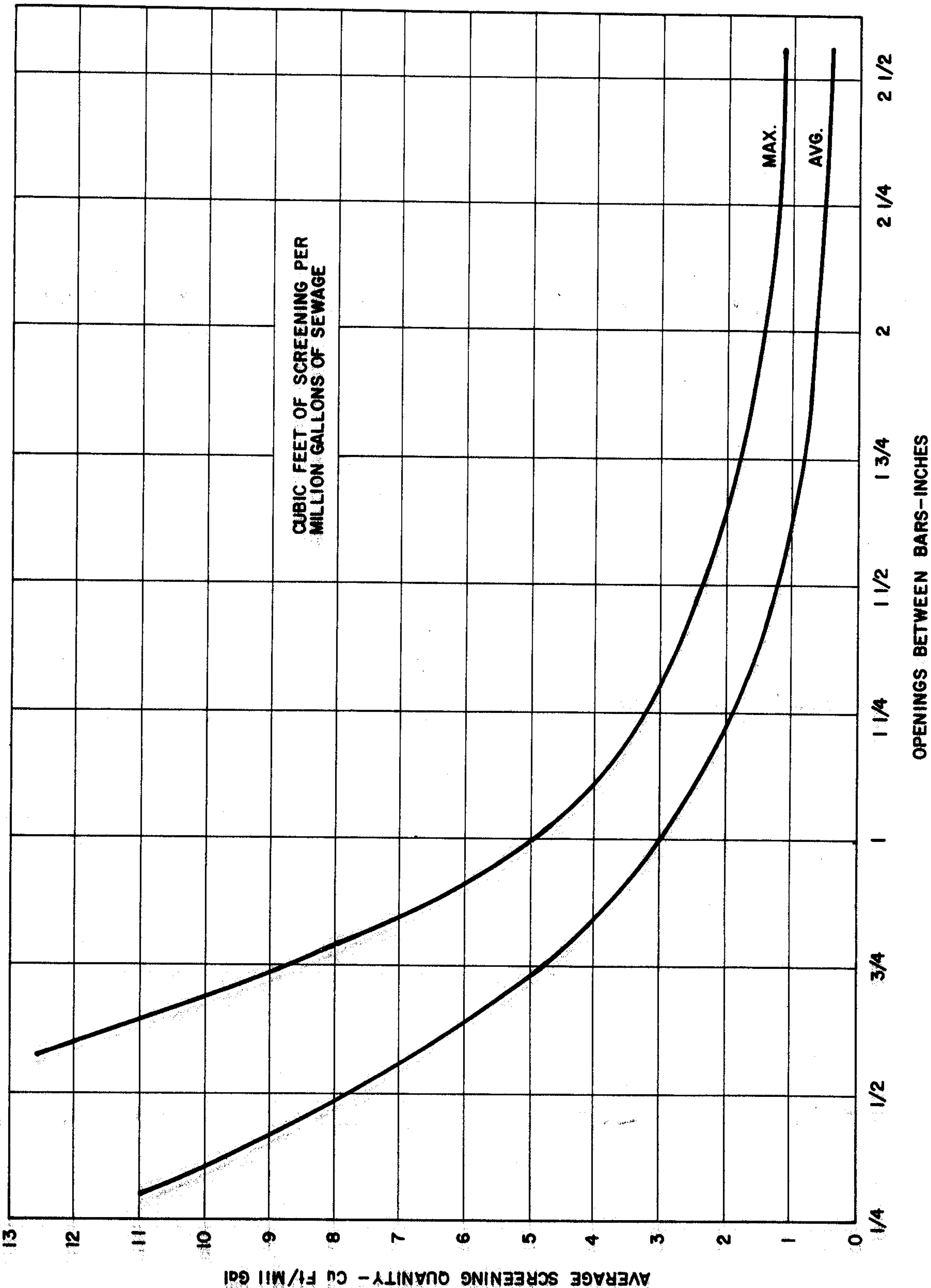
(4) Channel configuration. Considerable attention should be given to the design of the screen channel to make certain that conditions are as favorable as possible for efficient operation of the bar screen. The channel in front of the screen must be straight for 25 feet. Mechanical screens with bars inclined at an angle of 15 degrees from the vertical will be installed.

(5) Screenings. The graph shown in figure 7-2 will be used to predict the average amount of screenings that will be collected on the bar screen. The information required to make this estimate is flow and bar spacing. Grinding of the screenings (and returning them to the wastewater flow), incineration, and landfilling operations are satisfactory methods for disposal of the screenings.

(6) Design procedure. Select bar size and spacing and determine efficiency factor. Determine number of units desired. Divide total maximum daily flow or total maximum storm flow by the number of screens desired to obtain maximum flow per screen. The procedure is then as follows:

Maximum daily flow in mgd x 1.547 = maximum daily flow in cfs.

Maximum storm flow in mgd x 1.547 = maximum storm flow in cfs.



U. S. Ary Corps of Engineers

FIGURE 7-2 ESTIMATE OF SCREENINGS COLLECTED ON BAR SCREENS

$\frac{cfs}{2}$ = net area through bars for maximum daily flow.

$\frac{cfs}{3}$ = net area through bars for maximum storm flow.

Whichever of the above gives the larger value should be used for design.

$\frac{\text{Net area in square feet}}{\text{Efficiency coefficient for bars}}$ = gross area or channel cross-section wet area.

Minimum width of bar rack = 2 feet; Maximum width = 4 feet

$\frac{\text{Channel cross-section wet area}}{\text{Maximum desired width or depth}}$ = Corresponding depth or width

These figures are based on recessing channel walls 6 inches each side for chain tracks and screen frame. The overall width of screen frame is 12 inches greater than width of bar rack. If not possible to recess walls, the channel should be made 1 foot wider than figured above.

(7) Sample calculation. Assume:

Maximum daily flow = 4 mgd
Maximum storm flow = 7 mgd
Maximum allowable velocity through bar rack for maximum daily flow = 2 fps.

Then, using the design procedure in the preceding paragraph:

Maximum daily flow = 4 x 1.547 = 6.188 cfs.
Maximum storm flow = 7 x 1.547 = 10.829 cfs.

Since Q = Av, 6.188 = A x 2, and the net area A through the bars is 3.094 square feet. For a maximum allowable velocity through the bar rack of 3 fps during maximum storm flow, the net area through the bars must be 10.829/3 = 3.61 square feet. The gross area will be based on the larger of the two net areas, in this case 3.61 square feet. A rack consisting of 2-inch by 5/16-inch bars spaced to provide clear openings of 1 inch has an efficiency of 0.768 (table 7-1), yeilding:

$$\text{Gross Area} = \frac{3.61}{0.768} = 4.70 \text{ square feet}$$

The channel width in this case might be established at 3 feet, in which case the water depth would be 4.70/3.0 = 1.57 feet. This is a theoretical water depth which may be affected by subsequent plant units. The head loss through a bar rack is computed from the following equation:

$$h = \frac{V^2 - v^2}{45}$$

where:

h = head loss in feet
V = velocity through rack
v = velocity upstream of rack

or:

$$h = 0.0222\ (V^2 - v^2)$$

Again making use of $Q = Av$,

$$v = 10.829/4.70 = 2.3 \text{ fps}$$

Therefore:

$$\begin{aligned} h &= 0.222\ (3^2 - 2.3^2) \\ &= 0.222 \times 3.7 \\ &= 0.082 \text{ foot, or approximately 1 inch} \end{aligned}$$

If the screen is half plugged with screenings, leaves, and other debris: From $Q = Av$ the area is directly proportional to the velocity. In other words, if the area is cut in half, the velocity must double. The head loss therefore is:

$$\begin{aligned} h &= 0.0222\ (6^2 - 2.3^2) \\ &= 0.0222 \times 30.7 \\ &= 0.682 \text{ foot, or approximately 8-1/4 inch} \end{aligned}$$

The increase in head loss is over one-half foot as the screen becomes half plugged. The need for accurate control of the cleaning cycle, and protection against surge loads, is thus demonstrated.